measured. The exposures were from three to five minutes. Photographs are given in the second paper showing the displacement of the fringes for three different points in the spectrum. The results are summarised in the following table:—

Wave-length	Fresnel coefficient	Lorentz coefficient	Experimental value
4500	0·443	0·464	0·465
4580	0·442	0·463	0·463
5461	0·439	0·454	0·451
6870	0·435	0·447	0·445

The calculated probable error of the experimental result is about 1 per cent. of the latter.

The experiment decides conclusively in favour of the Lorentz coefficient. Not only does the absolute value of the result agree better with the latter, but so also does its variation with the wave-length, the figure for the experimental value being 1616 and the figures derived respectively from the Fresnel and Lorentz coefficients being 1572 and 1608. Thus the degree of accuracy has been pushed a stage further in what was regarded as one of our most accurate experiments.

SCIENCE AND WAR.

We are permitted to publish this week some passages from Sir William Osler's address to the Leeds Medical School on "Science and War" (Oxford: At the Clarendon Press. Price 1*s.* 6*d.* net). Sir William writes with authority and with distinction: and all who love good thoughts arrayed in good style ought to buy this address and read it with care. He keeps his head clear, though he has chosen a theme vast beyond imagination. The war transcends our powers of thought; so does science. The war has gone beyond us; so has science. Yet he is able, more than most of us, to measure the working together of the immeasurable forces of science and war: for he has always in his head, and in his heart, the duplicity of science. "I bring to life, I bring to death," says Science. In the war, my Lady Science is busy both ways. She employs artists in death and artists in life; she supplies them—so impartial are abstractions—with asphyxiating gases and with antiseptic dressings; she manufactures with equal mind high explosives and protective vaccines, submarines and motor-ambulances. What a thing it is to be an abstraction, a name for systematised thought; to have no morals, no likes or dislikes; to be nothing but a Latin word for the best way of doing what is to be done.

Sir William Osler, as a true man of science, gives an admirable and well-balanced account of this dual influence of scientific method on the war. He is not only a man of science: he is also a great physician, a notable artist in life. His account of one of the chief base hospitals in France is delightful reading; the speed and precision and modernity of the work achieved are above praise. A strong committee has already taken in hand the compiling of the medical and surgical history of the war. It will be a mighty book. The medical and surgical history of the American Civil War is in five huge volumes; we can scarcely have less than that for the present war.

Toward the end of the address, Sir William says what a good many of our great doctors are saying or thinking. "To one who is by temperament and education a Brunonian and free from the 'common antipathies' and 'national repugnances,' one sad sequel of the war will be, for this generation at least, the death of international science." He thinks that science will suffer grievously by some sort of boycott against Germany; he dreads what he calls "Chauvinism in science." He says that "an impassable intellectual gulf yawns between the Allies and Germany." We think that he makes too much of this fear. The gulf between the Allies and Germany is ethical, not intellectual. There will be friendships broken, and international medical congresses made impossible, and no more honorary degrees from German universities, and no hospitality for hospital workers, and so forth; but these losses will be easily tolerable. Science has her own ways of getting back a bit of her own.

The following extracts from Sir William Osler's address may serve to illustrate its wisdom and style:—

> In Time our civilisation is but a thin fringe like the layer of living polyps on the coral reef, capping the dead generations on which it rests. The lust of war is still in the blood: we cannot help it. There was, and there is as yet, no final appeal but to the ordeal of battle. Only let us get the race in its true perspective in which a thousand years are but as yesterday, and in which we are contemporaries of the Babylonians and Egyptians and all together within Plato's year. Let us remember, too, that war is a human development, unknown to other animals. Though nature is ruthless "in tooth and claw," collective war between members of the same species is not one of her weapons; and in this sense Hobbes's dictum that "war was a state of nature" is not true. The dinosaurs and pterodactyls and the mastodons did not perish in a struggle for existence against members of their own species, but were losers in a battle against conditions of nature which others found possible to overcome. In our own day the gradual disappearance of native populations is due as much to whisky and disease as to powder and shot, as witness in illustration of the one the North American Indian and of the other the Tasmanians.
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> Some of us had indulged the fond hope that in the power man had gained over nature had arisen possibilities for intellectual and social development such as to control collectively his morals and emotions, so that the nations would not learn war any more. We were foolish enough to think that where Christianity had failed science might succeed, forgetting that the hopelessness of the failure of the Gospel lay not in the message, but in its interpretation. The promised peace was for the individual—the world was to have tribulations; and Christ expressly said: "Think not that I am come to send peace on earth; I came not to send peace but a sword." The Abou ben Adhems woke daily from their dreams of peace, and lectured and published pamphlets and held congresses, while Krupp built 17-inch howitzers and the gun range of the super-Dreadnoughts increased to eighteen miles!
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> And we had become so polite and civil, so cultured in both senses of that horrid word, with an "Is thy

servant a dog?" attitude of mind in which we overlooked the fact that beneath a skin-deep civilisation were the same old elemental passions ready to burst forth.

In spite of unspeakable horrors war has been one of the master forces in the evolution of a race of beings that has taken several millions of years to reach its present position. During a brief fragment of this time—ten thousand or more years—certain communities have become civilised, as we say, without, however, losing the savage instincts ground into the very fibre of their being by long ages of conflict. Suddenly, within a few generations, man finds himself master of the forces of nature. In the fulness of time a new dispensation has come into the world. Let us see in what way it has influenced his oldest and most attractive occupation.

Science is a way of looking at the world taught us by the Greeks—a study of nature with a view of utilising her forces in the service of man. It "arose from the simplest facts of common experience, and grew by the co-operation of the mass of men with human intellect at its highest. And when developed it returns again to strengthen the common intelligence and increase the common good. Above all, more perfectly than any other form of thought, it embodies the union of past and present in a conscious and active force."[1] Man's latest acquisition, it has worked a revolution in every aspect of his life, without so far changing in any way his nature. He is still a bit bewildered, and not quite certain whether or not the invention is a Frankenstein monster. The promise of Eden of full dominion over nature has only been fulfilled in our day. The flower and fruitage has come suddenly within a couple of generations. Even the seed time was but a few years ago, for to the Heidelberg man, looking down the ages from the Glacial period, Aristotle and Darwin are contemporaries, Galen and Lister fellow practitioners. Steam and electricity have upset our weekday relations, and the theory of evolution our Sundays. Like a beggar suddenly enriched man has not yet found himself; and the old ways and old conditions often sort ill with the changing times. New bottles could not always be found for the new wine.

Organised knowledge, science, if living, must infiltrate every activity of human life. There was a difficulty in these islands, which of fruitful ideas, inventions, and discoveries have had the lion's share, but failed to grasp quickly their practical importance. The leaders of intellectual and political thought were not awake when the dawn appeared. The oligarchy who ruled politically were ignorant, the hierarchy who ruled intellectually were hostile. Read of the struggles at Oxford and Cambridge in the "fifties" and "sixties" of the last century to get an idea of the attitude of the intellectual leaders of the country towards "Stinks," the generic term for science. It was not port and prejudice, as in Gibbon's day, but just the hostility of pure medieval ignorance. Those in control of education were more concerned with the issues of Tract 90 and the Colenso case than the conservation of energy and "The Origin of Species." To take but one example. What a change it might have wrought in rural England if, in 1840, when the distinguished Prof. Daubeny was made professor of rural economy, Oxford could have had great State endowment for an Agricultural College. The seed was abundant, and the soil was good, and only needed the cultivation that has been given so freely by members of the past generation, with what results we see to-day at Oxford and Cambridge and in the new universities.

In two ways science is the best friend war has ever had; it has made slaughter possible on a scale never dreamt of before, and it has enormously increased man's capacity to maim and to disable his fellow man. In exploiting the peaceful victories of Minerva, Mars has added new glories to his name. More men are killed, more men are wounded, and consequently more men are needed than ever before in the history of the world's wars. From 1790 to 1913 there were 18,552,200 men engaged in the great wars, of whom 5,498,097 lost their lives (D. E. Smith). In the Balkan wars of 1912–13 there were 1,230,000 men engaged, of whom 350,000 were killed. In the Russo-Japanese War there were 2,500,000 men, of whom 555,900 lost their lives (D. E. Smith). It is estimated that in the present war more than twenty-one millions are engaged! As weapons have improved the losses will be yet greater, and we may expect that at least five or six millions of men in the prime of life will be killed. Within a few years artillery and high explosives, submarines, and aircraft have so revolutionised our methods of warfare that thousands are now destroyed instead of hundreds. The rifle and the bayonet seem antiquated, and one may go from hospital to hospital and not see a wound from the latter, and comparatively few from the former.

In three directions science has scored in a mission of destruction. What a marvellous adaptation of physics, pneumatics, and mechanics is displayed in a submarine, with which the highest standard of wholesale destruction is reached. In a few seconds a vast battleship, itself a product in every part of scientific genius, is blown asunder and a thousand men and boys sent flying into eternity. Or a colossal liner like the *Lusitania,* laden with harmless non-combatants, is torpedoed without warning and above 1200 perish miserably, to the inexpressible delight of a kultured nation, whose school children celebrated the event with a holiday.[2]

On land the field-guns, howitzers, and machine-guns have increased enormously our killing capacity; so much so, indeed, that in self-defence the armies have taken to earth, and from the North Sea to the Alps Europe has become a rabbit warren. High explosives, long-range accuracy, and quickness of fire have made the artillery arm the most effective of the Service. Every device of science has been pressed into use, and the aeroplanes with their observers and cameras have plotted the entrenched lines to checker boards, on to any square of which a rain of shell and shrapnel may be poured. The high-explosive shells, the "Jack Johnsons," and the "Black Marias" have played a great *rôle* in the present war, and not only do they kill and maim, but the shell-shock from commotion puts a large number of men out of action. Against the great Krupp howitzers the forts of Europe have gone down like cardboard houses.

Artillery and quick-firing machine-guns follow hard upon the torpedo as agencies of destruction. Against an oncoming enemy 20 per cent. of men and 60 to 80 per cent. of horses are hit by separate bullets within the "mown area."

Theoretically all is fair in war, but by common consent certain practices regarded as cruel are tabooed, such as the use of explosive bullets. Not so in the present war. Never before has anything been used by man to kill his fellow man equalled in diabolical capacity for cruelty the use by the Germans of irrespirable gas. Had it been a suddenly asphyxiating vapour, such as may have been the breath of the angel of death as he passed over the host of Sennacherib, the action would not perhaps have been thought any more reproachful (in war) than wholesale drowning by the torpedo. But this was a very different matter—agonising suffocation to those who could not escape; many for days gasped out their lives in a slow process of strangulation, others had a lingering illness with urgent dyspnœa, cough, and inflammation of the lungs. The worst types of cases were, I am told, appalling to witness—some who reached England were bad enough.

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[1] Marvin, "The Living Past," second edition, 1915.

[2] Owen Wister, "The Pentecost of Calamity," p. 55.

It is not a little remarkable that the aspect of the war which caught the popular fancy and from which so much was expected has proved comparatively harmless from a killing point of view. "The rain of ghastly dew" of Tennyson's vision, which the Wright brothers and Zeppelin have made possible, is more destructive of property than of life. But the mastery of the air is one of the greatest of the conquests of science. How Leonardo da Vinci would have rejoiced, in this day predicted so confidently by him, to see flocks of wonderful bird-men as much at home in the air as eagles! The development of aircraft and air-guns has added a new arm to the Service, but battles of the airy navies grappling with each other or attacked by shells from land leave few wounded, and the total killed so far is small. An enormous value for observation and the shock of righteous indignation roused all over the world by the Zeppelin murders of women and children have been, so far, the chief assets of the air.

Enough of this. Let us turn to the other side of the picture; let us see what science has done in a mission of salvation amid the horrors of war. Through the bitter experiences of the Napoleonic wars, of the Crimea, of the American Civil War, and more particularly of the recent campaigns, there has been evolved a wonderful machinery, replete with science, for the transport and care of the sick and wounded. There must be suffering—that is war—but let us be thankful for its reduction to a minimum, through the application in every direction of mechanical and other pain-saving devices.

If the foes of our own household, the "anti's," would spend a few days at a hospital for infectious diseases, see the modern methods, and learn a few elementary facts about immunity, they could not but be impressed with the applications of scientific horticulture to disease, and be lost in admiration of a technique of extraordinary simplicity and accuracy.

The second great victory of science in war is the prevention of disease. Apollo, the "far darter," is a greater foe to man than Mars. "War slays its thousands, Peace its ten thousands." In the Punjab alone, in twelve years, plague has killed two and a half millions of our fellow-citizens. This year two preventable diseases will destroy more people in this land than the Germans. The tubercle bacillus alone will kill more in Leeds in 1915 than the city will lose of its men in battle. Pestilence has always dogged the footsteps of war, and the saying is true—"Disease, not battle, digs the soldier's grave." Bacilli and bullets have been as David and Saul, and at the breath of fever whole armies have melted away, even before they have reached the field. The fates of campaigns have been decided by mosquitoes and flies. The death of a soldier from disease merits the reproach of Armstrong:—

> Her bravest sons keen for the fight have dy'd
> The death of cowards and of common men—
> Sunk void of wounds and fall'n without renown.

This reproach science has wiped away. Forty years ago we did not know the cause of any of the great infections. Patient study in many lands has unlocked their secrets. Of all the great camp diseases—plague, cholera, malaria, yellow fever, typhoid fever, typhus, and dysentery—we know the mode of transmission, and of all but yellow fever the germs. Man has now control of the most malign of nature's forces in a way never dreamt of by our fathers. A study of her laws, an observation of her facts—often of very simple facts—has put us in possession of life-saving powers nothing short of miraculous. The old experimental method, combined with the new chemistry applied to disease, has opened a glorious chapter in man's history. Half a century has done more than a hundred centuries to solve the problem of the first importance in his progress.

Lastly, in the treatment of wounds science has made great advances. The recognition by Lister of the relation of germs to suppuration, an outcome of Pasteur's work, has done away with sepsis in civil life. High explosives, shell, and shrapnel make wounds that are at once infected by the clothing and dirt, and are almost impossible to sterilise by any means at our command, but with free drainage, promotion of natural lavage from the tissues by Wright's method, and the use of antiseptics when indicated, even the most formidable injuries do well. The terrible laceration of soft parts and bones adds enormously to the difficulty of treatment. The X-ray has proved a boon for which surgery cannot be too grateful to Röntgen and to the scores of diligent workers who have given us a technique of remarkable accuracy. Other electrical means for detecting foreign bodies have also given good results.

Of the germs blown into wounds from the soil and clothing and skin the pus-formers are the most numerous and most important. Two others have proved serious foes in this war, the germ that causes gas gangrene and the tetanus bacillus. I am told that methods of treatment of wounds infected by the former are giving increasingly good results. The soil upon which the fighting has occurred in France and Flanders is rich in the spores of the tetanus bacillus; the disease caused by it was at first very common and terribly fatal among the wounded. For centuries it has been one of the most dreaded of human maladies, and justly so, as it is second to none in fatality and in the painful severity of the symptoms. No single aspect of preventive medicine has been more gratifying in this war than the practical stamping out of the disease by preventive inoculation. In the first six months of this year only thirty-six of those who were inoculated within twenty-four hours of being wounded suffered from tetanus.

And what shall be our final judgment—for or against science? War is more terrible, more devastating, more brutal in its butchery, and the organisation of the forces of nature has enabled man to wage it on a titanic scale. More men will be engaged and more will be killed and wounded in a couple of years than in the wars of the previous century. To humanity in the gross science seems a monster, but on the other side is a great credit balance—the enormous number spared the misery of sickness, the unspeakable tortures saved by anæsthesia, the more prompt care of the wounded, the better surgical technique, the lessened time in convalescence, the whole organisation of nursing; the wounded soldier would throw his sword into the scale for science—and he is right.

NOTES.

THE Romanes Lecture on "Science and the Great War," delivered by Prof. E. B. Poulton at Oxford on December 7, and published by the Clarendon Press, was a scathing indictment of the ineptitude of the lawyer-politicians who possess a dominating influence on national affairs, and a plea for a fuller use of